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ABSTRACT

This module, one of 25 on vocational education training for careers in environmental health occupations, contains self-instructional materials on using an electric single pan analytical balance. Following guidelines for students and instructors and an introduction that explains what the student will learn are three lessons: (1) identifying and explaining the function of each part required to operate the electric single pan analytical balance; (2) operating the balance to weigh accurately a sample object; and (3) using the balance to add desired weights of different substances to a container to determine the unknown weight of a sample. Each lesson contains objectives, recommended methods and locations for practice, performance criteria, equipment and supplies to perform a task, detailed step-by-step instructions for learning a task, and performance exercises. Two performance tests cover operating an electric single pan analytical balance and finding weights of substances added to containers. (CT)

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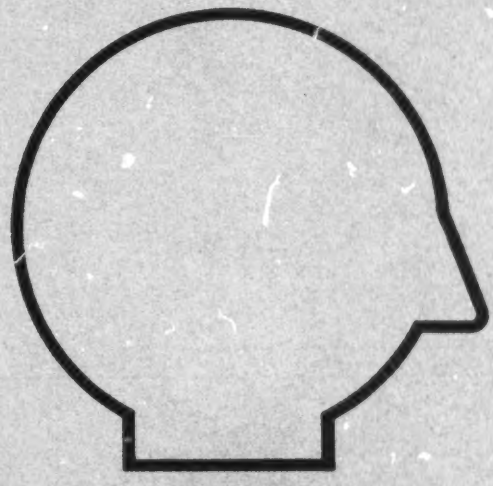

# Using an Electric Single Pan Analytical Balance

## Module 18

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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## FOREWORD

The Curriculum and Instruction Branch of the Office of Vocational and Adult Education, U.S. Department of Education, identified a need to improve the training opportunities for vocational education students interested in pursuing careers in environmental health. To fulfill that need, Consumer Dynamics, Inc., a Rockville, Maryland, based company, was awarded the contract to develop performance-oriented, competency-based modules in the environmental health sciences.

USING AN ELECTRIC SINGLE PAN ANALYTICAL BALANCE is one of the modules in the series, "Vocational Education Training in Environmental Health Sciences." The module content is based on selected materials in the environmental health field. The module is intended to supplement existing course materials.

CONTENTS


FOREWORD .....i

USING THESE SELF-INSTRUCTION MATERIALS .....1
Guidelines For Students .....1
Guidelines For Instructors .....2

INTRODUCTION .....3
Background .....3
What You Will Learn .....4

LESSON ONE .....5
Objective .....5
Where And How To Practice .....5
How Well You Must Do .....5
Things You Need .....5
Getting There--Steps .....6
Exercises .....11

LESSON TWO .....12
Objective .....12
Where And How To Practice .....12
How Well You Must Do .....12
Things You Need .....12
Getting There--Steps .....13
Exercises .....17

LESSON THREE .....18
Objective .....18
Where And How To Practice .....18
How Well You Must Do .....18
Things You Need .....18
Getting There--Steps .....19
Exercises .....24

PERFORMANCE TEST .....26
Operating An Electric Single Pan Analytical Balance .....26
Finding Weights Of Substances Added To Containers .....27

REFERENCES .....28

## USING THESE SELF-INSTRUCTION MATERIALS

This self-instruction learning package or module is designed to allow both students and instructors flexibility of use. Although primarily intended for use in existing training programs, the module can be used by anyone interested in learning new skills or perking up old ones. Therefore, two sets of guidelines are presented--one set addressed to students and the other set addressed to instructors. First, find out how you, the student, should use the materials in this book.

## GUIDELINES FOR STUDENTS

**Take the Performance Test as a pretest.**

When you pick up this book and work through it, your goal will not be a letter grade or a high score on an exam. Instead, you will work to develop skills that you can measure. You will not have to worry about how well some else is doing. Before you start work on this book, you should, first, find out if you have sufficient skills to start training by reading through the section called PERFORMANCE TEST. If you think you can do all or most of the items in this test, ask your instructor to obtain the necessary equipment and supplies. Although you do not need special preparation in a laboratory science to work through this module, you should have some working knowledge of science. You do not have to have specialized skills to enter training in this module.

**Work on parts you need to practice.**

If you do everything well, according to the criteria in the Performance Test guidelines, you will not need to spend time working on this module. If after taking the Performance Test you discover there are parts you need to practice, follow the key to each item in FOR FURTHER STUDY.

**Work straight through each lesson in the order presented.**

Should you decide to completely work through this book, begin with the INTRODUCTION and go straight through each of the three lessons. The lesson begins with the OBJECTIVE of the training. Follow the instruction for each part in the order presented. Practice each step in a lesson until you can do it according to the criteria stated for the step. At the end of a lesson, do the EXERCISES. When there are audiovisuals listed at the end of a lesson, ask your instructor for help in obtaining them.

## USING THESE SELF-INSTRUCTION MATERIALS

**Take the Performance Test as a posttest.**

Finally, after you have mastered all of the exercises in each lesson, ask your instructor to watch you do each item in the Performance Test. The items in the Performance Test are intended for use as a posttest to evaluate the quality of your performance. Turn now to the Performance Test.

## GUIDELINES FOR INSTRUCTORS

**Approach**

The approach of these materials is to provide the students with the skills to accurately weigh objects and substances using a single pan electric analytical balance. The module uses instrumentation commonly found in technical laboratories. You may find that the instrument presented in this module is a different make or module from the one you have available. You may need to write supplementary instructions to point out the equipment differences. The skills tested on the Performance Test are designed for use with any make and model of instrumentation.

**Independent Study**

Students can work independently and at their own pace. Depending on the time frame you set for completing each lesson, you may want to start a group off in each lesson with a demonstration and informal presentation.

**As a Laboratory Workbook**

Alternatively, you may choose to use this module as a laboratory workbook in a structured laboratory session. With this option, you may allow students greater access to your assistance, especially in watching them perform the pre- and posttest portions of the training.

**General Instructions**

Read through each lesson to anticipate what equipment and supplies you will need to make available for students to use. Also, order any audiovisuals or reading materials you think may present a complementary perspective to the training in this module. Use the items in the Performance Test as the minimum requirements for gauging successful completion of the training.

# INTRODUCTION

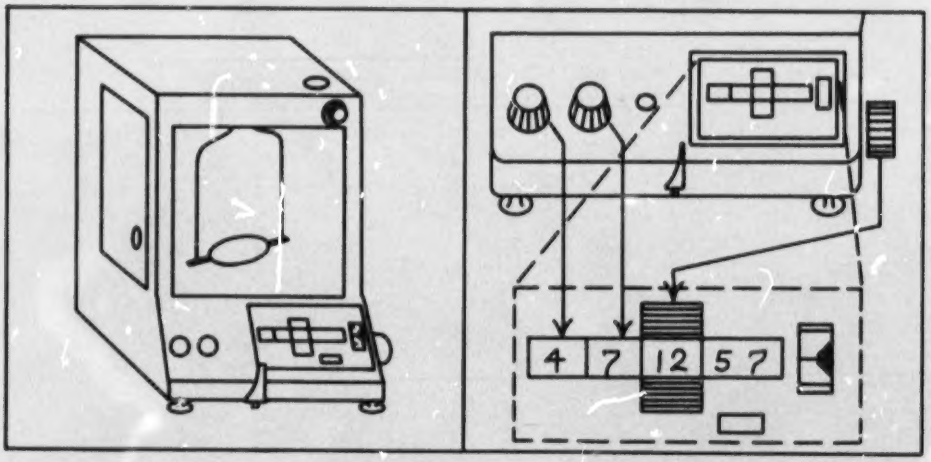
## BACKGROUND

One of the tasks the environmental health technician or environmental science technician may have to perform is measuring accurately and precisely the weight of solids, liquids, various chemical compounds, organisms, or particulate matter on filters. In the past, weighing an object to within 0.001 grams (g) required the use of a totally mechanically operated two-pan analytical balance. To make accurate measurements, the technician had to follow a laborious procedure to first zero and then weigh an object using a calibrated set of standard weights. Today, electronics has made quantitative weighing much easier and more accurate.

Depending on the make and model of the electronic analytical balance, it is possible to weigh, easily and quickly, objects as heavy as 1,000 g and as light as 0.0001 g. This range of weights covers many of the weighing assignments you may typically have if you are employed by virtually any company that requires you to take environmental samples or perform environmental monitoring.

## WHAT YOU WILL LEARN

When you have finished working through the steps and exercises in this book, you will be able to use an electric single pan analytical balance to weigh an object that weighs between 0.0001 g and 99 g.




You will learn these skills in three lessons:

- o Lesson One

  You will be able to identify and explain the function of each part required to operate the electric single pan analytical balance.

- o Lesson Two

  You will be able to operate the balance to accurately weigh a sample object.

- o Lesson Three

  You will be able to use the balance to add desired weights of different substances to a container, and to determine the unknown weight of a sample.

## LESSON ONE

### OBJECTIVE

You will be able to identify and explain the function of each part required to operate the electric single pan analytical balance.

### WHERE AND HOW TO PRACTICE

The balance should always be used in a laboratory away from traffic and cross-drafts in the room whenever possible. The balance should be placed on a solid, level tabletop to eliminate vibrations that could affect measurement accuracy. The temperature and the humidity should be controlled and be as constart as possible to eliminate these variables when weighing.

Read through each step to identify any questions you may have. Request help from your instructor whenever you are unable to resolve a problem concerning a step.

### HOW WELL YOU MUST DO

You must be able to name within 10 minutes all externally operated parts on the balance and describe how they work.

### THINGS YOU NEED

You will need the Mettler H31 electric single pan analytical balance* to work through the steps and exercises in this lesson, since other balances may not operate the same way.

Instructions: Now turn to the next page and begin work on Lesson One, "Getting There--Steps."

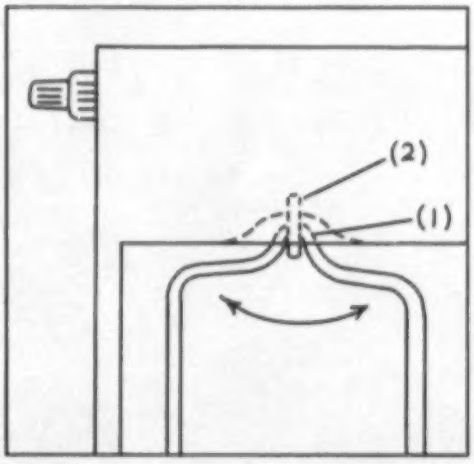
*The steps in this lesson refer to the Mettler H31 balance, but its use is not intended to be an endorsement by the U.S. Department of Education. The equipment shown in this module was selected because it is widely available and commonly used.

## GETTING THERE--STEPS

STEP 1

Slide open one of the doors on the weighing chamber. Look to see that the hook (1) on the pan arm swings freely on the hook (2) extending from the balance beam. If the pan is sitting askew, accurate weighings cannot be done.

KEY POINT 1

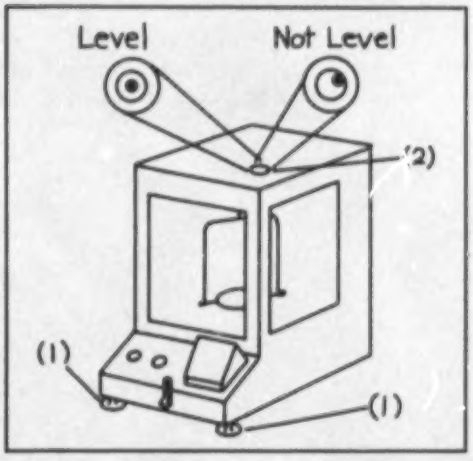



Check the position of the hooks to make sure the pan arm is resting properly.

STEP 2

Find the two threaded feet (1) on each side of the balance near the front bottom edge. Locate the level indicator (2) on top of the balance. While watching the bubble, turn the feet. When the bubble is in the center of the black ring, the balance is level and ready for making accurate weighings.

KEY POINT 2

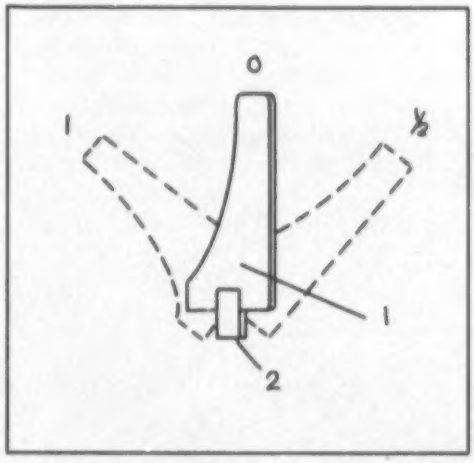



Turn the threaded feet to level the balance.

STEP 3

While sitting in front of the balance, find the pan arrest lever (1) on the front of the balance. Locate the safety catch, a small button (2), on the lever.* Notice the three marked positions indicated above the lever. By placing the lever at one of the markers, the pan is raised or lowered into an arrest or into a weighing position.

KEY POINT 3

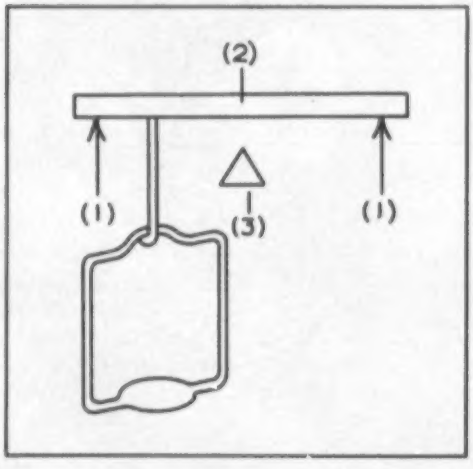



Use the pan arrest lever to place the pan into an arrest or weighing position.

STEP 4

Move the pan arrest lever to the "0" position, if it is not already there. This is the full arrest position, which should be used when weighing is not in progress. At "0" the lever causes mechanical stops (1) to physically lift the balance beam (2) completely off the knife edges (3) on which the pan rests when weighing is done.

KEY POINT 4



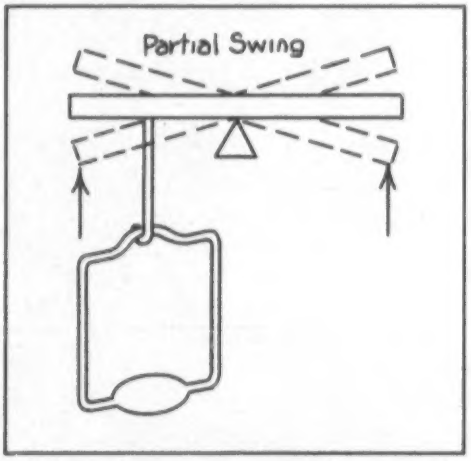

Move the lever to the "0" position when not weighing. The beam is up, and the stops are up.

*Some balances do not have safety catches, and some balances have the release arm on the side rather than on the front.

STEP 5

Move the arrest lever to the "1/2" position to do rough weighing. At this position the beam is lowered to the knife edges but the stops allow the pan to swing only slightly, as indicated in the Key Point.

KEY POINT 5

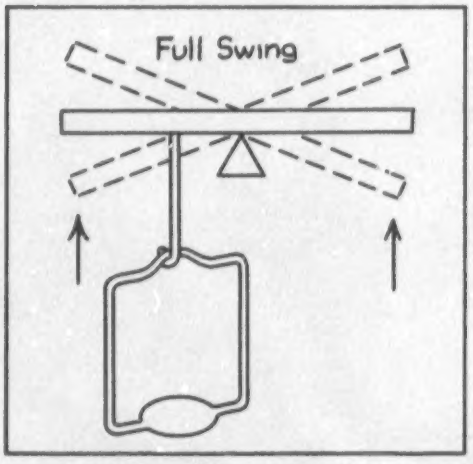



Move the lever to the "1/2" position to do rough weighing. The beam is down, and the steps are partially up.

STEP 6

Move the arrest lever to the "1" position to do the final weighing. At this position the beam is lowered to the knife edges and the stops are far enough away from the beam to allow the pan to swing freely, as shown in the Key Point. Return the arrest lever to the "0" position for the remaining steps in this lesson.

KEY POINT 6

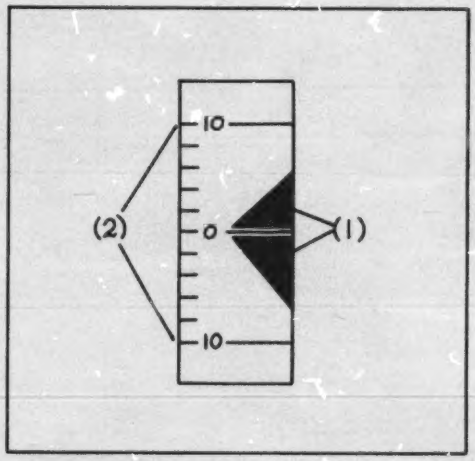



Move the arrest lever to the "1" position to do the final weighing. The beam is down, and the stops are completely down.

STEP 7

Look at the weight display. On the far right of the display window, find the reference pointer (1). The vernier scale (2) appears behind the reference pointer when the pan arrest lever is moved to either the "1" or the "1/2" position. When doing an actual weighing, add weight or subtract weight until the "0" on the vernier is centered between the two points of the reference pointer.

KEY POINT 7

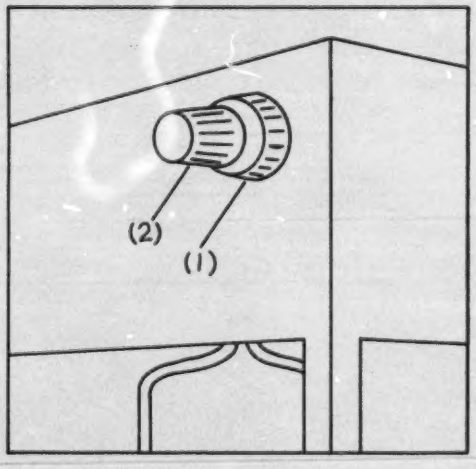



When the pan is released, add weight to the pan until the "0" is aligned with the reference pointer.

STEP 8

Find the two knobs at the top upper right of the balance. When weighing, use the larger one, the fine adjust knob (1), to fine adjust the zero point shown by the reference pointer when there are no weights on the beam or the pan. Use the inside one, the optical scale adjust knob (2), for setting the vernier optical scale back to zero to compensate for container weight on the pan.

KEY POINT 8




Use these knobs to fine adjust the zero point and to eliminate having to find the weight of the container.

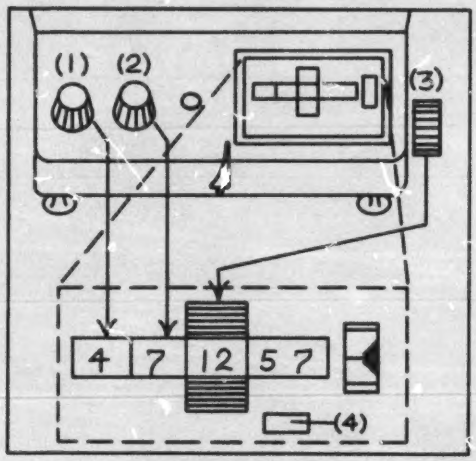
STEP 9

When weighing, add weight to the beam by dialing weights, using Knobs 1, 2, and 3:

- o Dial Knob 1 to add 10-g amounts.
- o Dial Knob 2 to add 1-g amounts.
- o Dial Knob 3 to add milligram amounts.

The digits 57, shown in the Key Point, are not dialed mechanically but are dialed electronically when weight is placed on the pan.

KEY POINT 9




Dial Knobs 1 through 3 to add weight mechanically.

STEP 10

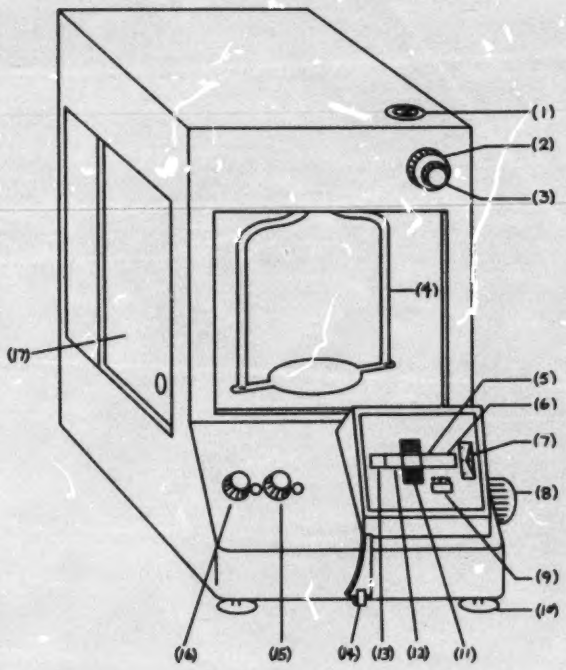
Directly below the weight readout display, find the filling guide. It is shown in Key Point 9 as item 4. By showing the approximate weight, it permits the operator to quickly add materials to the pan after dialing the desired weignt.

KEY POINT 10

Use the filling guide to rapidly add weight to the pan.

## EXERCISES

Instructions: Use Lesson One to learn all the names and functions of the parts of the electronic balance. Then label the following drawing. You must be able to describe in your own words how a part works or what the label means. Perform this exercise within 10 minutes.




1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____

## LESSON TWO

### OBJECTIVE

You will be able to operate the balance to accurately weigh a sample object.

### WHERE AND HOW TO PRACTICE

Practice this lesson in the same location as Lesson One. Before attempting to do a step, read through it and be sure you understand what you are to do or learn.

### HOW WELL YOU MUST DO

You must be able to obtain the average of three sample weighings, each of which must be accurate to within $\pm$0.0001 g, and be able to do the weighings within 10 minutes or less.

### THINGS YOU NEED

In addition to the equipment you used in Lesson One, you will need the following:

- pan balance weight, 5 g $\pm$ 0.5 g
- forceps, weight or general-purpose.

Instructions: Now turn to the next page and begin work on Lesson Two, "Getting There--Steps."

## GETTING THERE--STEPS

| STEP | KEY POINT |
| --- | --- |
| STEP 1<br><br>Make sure the balance is plugged in. At the beginning of each weighing session, check to see that the balance is level. Check the bubble indicator. If the bubble is not centered, turn the threaded feet to center the bubble. | KEY POINT 1<br><br>Center the bubble to level the balance. |
| STEP 2<br><br>Prepare the balance for zeroing. Check the balance pan. Make sure that it is clean and that nothing has been placed on it. If it is not clean, hold the pan with one hand and with the other sweep the pan with a camel's hair brush. Make sure the pan is swinging freely. If it must be adjusted, make sure the arrest lever is in the "0" position; any jarring, even in the full arrest position, can make the pan jump off the hook. Close the weighing chamber doors. Make sure the weight readouts are all at 0 g. Pull out the pan arrest lever so that it is free to move. Press in the safety catch before attempting to move the lever from the "0" position. Move the lever to the full "free" position ("1"). The pan will sway gently. | KEY POINT 2<br><br>Before zeroing, clean and clear the pan, close the doors, press the safety catch, and move the arrest lever to "1". |

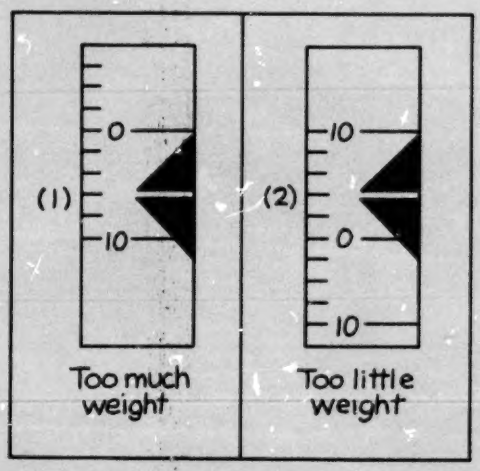
| STEP | KEY POINT |
| --- | --- |
| STEP 3<br><br>Watch the 0.1-g and 0.01-g readout scales. Turn the optical scale knob until you read 0 g. Now watch the reference pointer. Use the fine zero adjustment to align the zero on the vernier scale with the center of the reference pointer. The balance is now zero adjusted. Move the pan arrest lever to the full arrest position ("0"). | KEY POINT 3<br><br>Zero the center readout display and the reference pointer. |
| STEP 4<br><br>Open the door to the weighing chamber. Pick up the brass weight with a forceps and place it in the center of the pan. Do not touch the pan with your hands because you can add grease or moisture that can temporarily change the weight. Do not jar the pan because you can damage the electronic balance mechanism. Close the door to the chamber and wait 5-10 seconds for the pan to stop swinging. | KEY POINT 4<br><br>Do not handle any object you are going to weigh. |

STEP 5

Move the arrest lever to the "1/2" position. Since you know that the pan weight is 5 g ± 0.5 g, add 6 g in 1-g amounts. After you add the 6th gram, look at the reference pointer. If the lower part (1) of the vernier scale is behind the pointer, too much weight has been added to the beam. Subtract 1 g and check the pointer. If the upper part (2) of the scale is now behind the pointer, then too little weight has been added to the beam. Dial decimal amounts by adding or subtracting weight, depending on which way the vernier scale settles behind the pointer. Obtain a weight accurate to 0.0001 g. Record the weight here:

_____

KEY POINT 5




Use the reference pointer to indicate whether to add or subtract weight from the beam.

STEP 6

If the readout on the vernier scale is hard to read and appears fuzzy, move the pan arrest lever to full arrest. Let the balance sit for about 5 seconds and then move the arrest lever back to the "1" position and continue weighing.

KEY POINT 6

Arrest the pan if you cannot obtain a clear reading.

STEP 7

To make sure you have weighed the sample correctly, repeat the weighing procedure in Steps 5 and 6 two more times.

Record the second weight here: _____

Record the third weight here: _____

Add the three weights together and divide by three to obtain the average. Record the average here: _____

After obtaining the final weight, return the arrest lever to the full arrest position. Push in the arrest lever to lock it into place. Open the door to the weighing chamber and remove the sample, using the forceps--do not touch the sample or the pan.

KEY POINT 7

Repeat the same weighing two more times to obtain an average weight.

## LESSON TWO

### EXERCISES

Instructions: Practice weighing other standard pan weights, watch glasses, small beakers, crucibles, and filters. Weigh samples ranging from 1 g to 90 g.

## LESSON THREE

### OBJECTIVE

You will be able to use the balance to add desired weights of different substances to a container, and to determine the unknown weight of a sample.

### WHERE AND HOW TO PRACTICE

In this lesson you will again do all your work in the laboratory.

### HOW WELL YOU MUST DO

You must be able to make weighings that are accurate to ±0.0001 g, do each weighing within 10 minutes, and prevent spills on the balance or in the work area.

### THINGS YOU NEED

In addition to the equipment that you used in Lessons One and Two, you will need:

- o two 100-ml beakers (glass or plastic)
- o one 50-ml beaker (glass or plastic)
- o glassware detergent, distilled water, and acetone (reagent-grade)
- o weighing spatula, medium-sized
- o weighing spatula, small-sized
- o weighing paper
- o camel's hair brush
- o teaspoon measure
- o container of salt
- o calcium carbonate, 1 g (powdered)
- o calcium chloride dihydrate, 1 g.

Instructions: Now turn to the next page and begin work on Lesson Three, "Getting There--Steps."

## GETTING THERE--STEPS

STEP 1

Clean the area around the balance, including spills, and remove contaminated glassware and utensils. Clean two 100-ml beakers with laboratory glassware detergent. Rinse each container with tapwater, distilled water, and then acetone to speed drying. Also clean the weighing spatulas.

KEY POINT 1

Prior to weighing, clean your work area, all equipment, glassware, and utensils you will be using.

STEP 2

Make sure the balance is level. Zero the balance carefully as you did in Steps 1 through 3 in Lesson Two.

KEY POINT 2

Never begin weighing without first leveling and zeroing the balance.

STEP 3

Weigh an empty beaker. Make sure the arrest lever is on the full arrest position ("0") before placing the beaker on the pan. Since you will not be reweighing this container, place it on the pan with your hands. However, if you were to heat the contents or add chemicals to it and then reweigh it, you must not touch the container from the time it is cleaned; handle the container with laboratory tongs to prevent oil and dirt on your hands from adding weight to the beaker.

KEY POINT 3

Use tongs, not hands, to handle objects that must be reweighed.

STEP 4

Move the arrest lever to the "1/2" position. Add weight to the beam and watch the reference pointer. When the approximate weight of the beaker is reached, fully release the pan. Follow the weighing procedures in Steps 4 through 6 of Lesson Two to obtain the empty weight (tare weight) of the container. Record the tare weights here:

(1) _____

(2) _____

(3) _____

Average _____

Move the arrest lever to the "0" position.

KEY POINT 4

Find the approximate weight with the arrest lever in the "1/2" position.

STEP 5

Fill the second beaker 1/4 full of salt. Reseal the salt container and put it aside. Scoop out a rounded teaspoon of salt. Using the straight edge of the spatula, scrape off enough salt to leave a level teaspoon. Carefully add the salt to the beaker on the pan. Do not drop salt on the pan. Weigh the beaker plus salt. Record the weights here:

(1) _____

(2) _____

(3) _____

Average _____

Return the arrest lever to full arrest ("0").

KEY POINT 5

Do not spill materials on the pan or in the weighing chamber.

STEP 6

Determine the weight of the salt by subtracting the average weight of the container (Step 4) from the average weight of the salt plus container (Step 5). The weight of the salt is:

_____

KEY POINT 6

To find the weight of the salt, subtract the weight of the beaker from the total weight.

STEP 7

With the beaker and salt still on the pan, add 1.0000 g of salt to the beaker by following this procedure: Release the arrest lever to the "1/2" position. Using the large spatula, scoop out a small amount of salt from the beaker on the table. Slowly add the salt to the beaker until the readout is 0.99 g. Turn the arrest lever to "1" and continue adding salt until a readout of 1.0000 g is reached. If you add too much salt, arrest the pan to the "0" position, scoop out a little, and begin adding salt again. Continue this cycle until the beaker containing the salt weighs exactly 1.0000 g more than the grams recorded in Step 6. When you are finished, do not return salt back to the stock bottle. Throw the salt away. Returning it to the stock bottle could contaminate the whole bottle.

KEY POINT 7

Do not reuse leftover materials.

| STEP 8 | KEY POINT 8 |
| --- | --- |
| When you finish the weighing, check the zeroing of the balance. When weighing several samples consecutively, periodically check the zeroing adjustments. Place the pan on full arrest. Remove the beaker and salt from the pan. If any salt was spilled, carefully remove the pan by lifting it slightly and pulling it off the hook. Using a camel's hair brush, sweep any loose granules of salt off the pan into a waste receptacle. Clean up any spills of salt from the pan and from the bottom of the scale. Replace the pan, making sure it swings freely on the hook. | After weighing, check the zeroing, fully arrest the pan, and clean up the balance and work area. |

## LESSON THREE

### EXERCISES

Instruction 1: Weigh and record the weight of 25 mg of calcium carbonate. Use the techniques you learned in Lesson Three.

Weight of container _____

Weight of container + calcium carbonate _____

Weight of calcium carbonate _____

Instruction 2: Weigh and record the weight of 35 mg of calcium chloride dihydrate ($CaCl_2 2H_2O$). Use the techniques learned in Lesson Three.

Note: Calcium chloride has the tendency to absorb water from the air; hence, the sample will change weight as you try to weigh it. To prevent weight gain due to water, place a small beaker (50 ml) containing $CaCl_2 2H_2O$ in a desiccator.

After you remove some of the chemical from the beaker, replace it in the desiccator. Work quickly.

Instruction 3: Obtain a piece of weighing paper and any powdered chemical. Weigh and record the weight of the powder using the weighing paper. Use the techniques presented in Lesson Three except substitute the weighing paper for the beaker and the powder for the salt.

Weight of paper _____

Weight of paper + powder _____

Weight of powder _____

Instruction 4: Determine the area of an irregularly shaped wilderness area on a map. You can use the electronic analytical balance to figure out the area.

Obtain a standard map such as a USGS topographical map. Draw on the map an area with an irregular shape. Cut the area out of the map. Find the weight and record it here: _____. Find the scale of the map; for example, 1 inch = 1 mile. Carefully and accurately measure 1 square inch and cut it out of the map. Weigh the 1-inch square of paper. Record the weight here: _____.

Calculate the area using this general formula:

$$\frac{\text{Weight of irregular}}{\text{weight of known}} = \text{area of irregular.}$$

Follow this example before calculating, in square miles, the area of the map piece you weighed:

If the weight of irregular area is 35.75 g, and

the scale of the map is 1 inch = 1 mile, and

the weight of a 1-inch square of map paper is 0.09 g, perform the following calculation:

$$\frac{35.75 \text{ g}}{0.09 \text{ g/square inch}} = 397.22 \text{ square inches}$$

Answer:

Because 1 inch equals 1 mile, and 1 square inch equals 1 square mile, 397.22 square inches equals 397.22 square miles.

## PERFORMANCE TEST

Instructions: Check your skill level or progress by working through each of the items in this test. If you can perform each item as required, place a check in the space provided. When all of the items are checked, you are ready to demonstrate your skills to your instructor. You may use the following list if needed. You will be considered trained in a skill after your instructor approves your performance of each of the following items:

### OPERATING AN ELECTRIC SINGLE PAN ANALYTICAL BALANCE

No. 1 _____ Level the balance by adjusting the threaded feet to center the bubble in the level indicator.

No. 2 _____ Prepare the balance for zeroing by clearing and cleaning the pan, removing all weight from the beam, closing the chamber doors, and fully releasing the pan.

No. 3 _____ With the balance ready for zeroing, align the zero on the vernier scale with the center of the reference pointer.

No. 4 _____ Place an object that will be reweighed on the center of the pan so that it will be free from the dirt, grease, or moisture of handling.

No. 5 _____ Dial weight onto the beam, referring to the reference pointer to decide whether too much or too little weight is added.

No. 6 _____ Weigh standard Class S-1 balance weights of 2, 5, 10, 20, and 50 g to within ±0.0001 g.

## PERFORMANCE TEST

FOR FURTHER STUDY

If you could not perform one or more of the six items above, review and practice the following lesson steps:

No. 1
Lesson One, Step 2; Lesson Two, Step 1

No. 2
Lesson Two, Step 2

No. 3
Lesson Two, Step 3

No. 4
Lesson Two, Step 4; Lesson Three, Step 3

No. 5
Lesson Two, Step 5

No. 6
Lesson Two, Step 7

## FINDING WEIGHTS OF SUBSTANCES ADDED TO CONTAINERS

No. 1 _____ Obtain the tare weight of a container in 5 minutes.

No. 2 _____ Add a desired volume of a substance to a container, and find the weight of the substance in 10 minutes.

No. 3 _____ Add 1.0000 g of a substance to a tared container in 5 minutes.

FOR FURTHER STUDY

If you could not perform one or more of the three items above, review and practice the following lesson steps:

No. 1
Lesson Three, Step 3

No. 2
Lesson Three, Steps 5 and 6

No. 3
Lesson Three, Step 7

## REFERENCES

U.S. EPA, Learner's Guide, "Water Quality Monitoring--An Instructional Guide for the Two-Year Quality Monitoring Curriculum," Washington, DC, 1978.